

Draft Statewide River, Miss. Pool & Pepin Eutrophication Criteria

as presented to

Mississippi River Forum

Steve Heiskary

With assistance from:

Will Bouchard, Dennis Wasley, Howard Markus & Norman Senjem

Minnesota Pollution Control Agency

October 2010





Minnesota
Pollution
Control
Agency

Outline

- Statewide River Eutrophication Criteria
- Linkage with Lake Pepin & Mississippi River navigational pool eutrophication criteria;
- Challenges in Applying the Criteria
- Summary & Timelines



Need for River Nutrient Standards

- Nutrient enrichment negatively impacts aquatic biota and recreation
- USEPA – States should develop nutrient criteria for lakes, streams, wetlands (must develop may be more accurate based on recent Florida & Wisconsin cases)
- MN promulgated ecoregion-based lake eutrophication standards in 2008
- MN will promulgate river eutrophication standards in the 2010-2012 rulemaking





Minnesota
Pollution
Control
Agency

Statewide river criteria development

- Document relationships among nutrients, suspended algae, BOD, diurnal DO flux (daily max DO-min DO), fish, & inverts;
- Identify threshold concentrations;
- Assign numeric criteria based on above & supporting information;
- Numeric translator to address excess attached algae (periphyton);
- Adopt criteria into Minnesota's water quality (Ch. 7050) standards





Minnesota
Pollution
Control
Agency

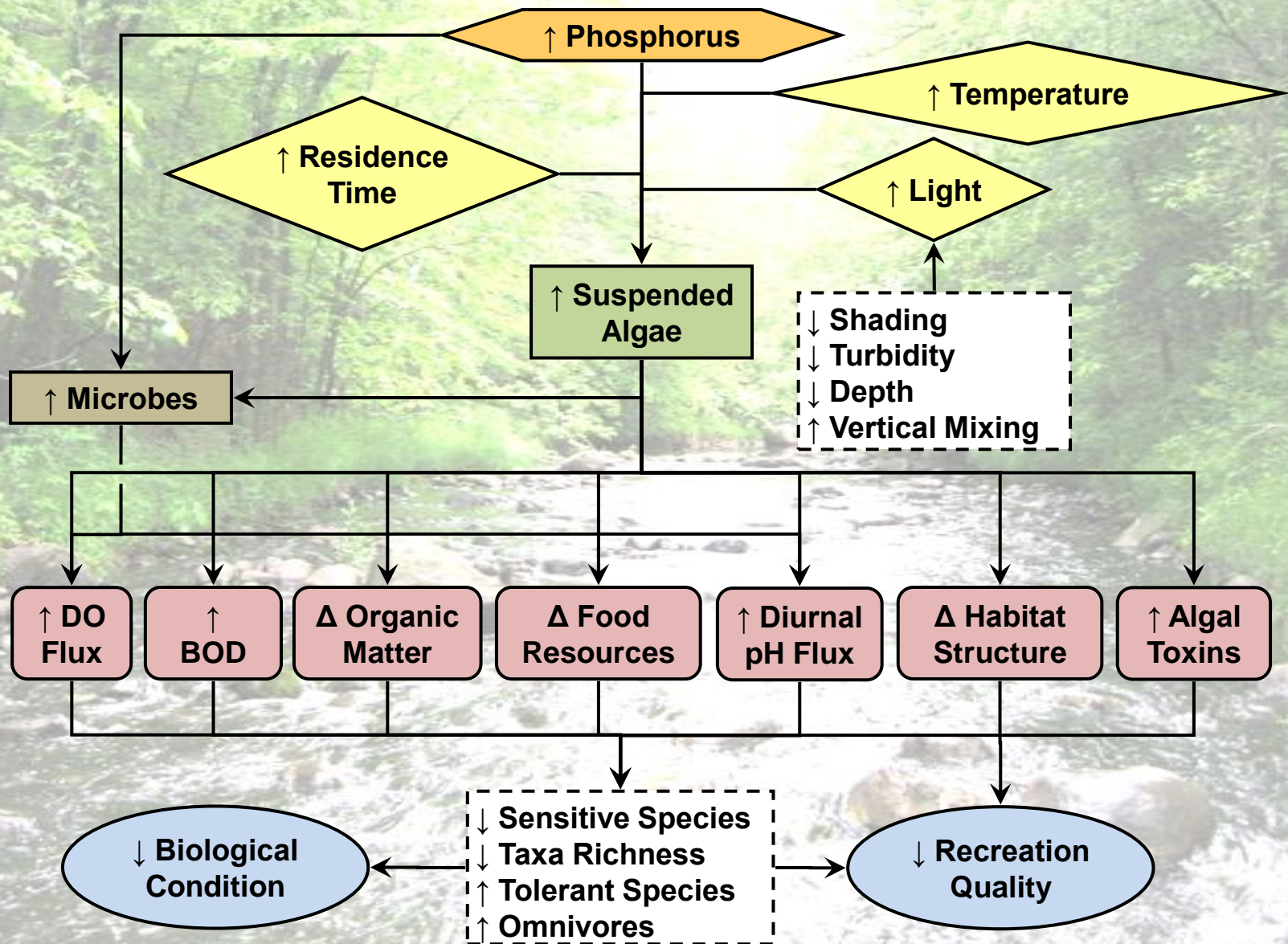
Draft river eutrophication criteria (summer-means)

	Nutrient	Response		
Region	TP μg/L	Chl-a μg/L	DO flux mg/L	BOD ₅ mg/L
North	55	<10	≤4.0	≤1.5
Central	100	<20	≤4.5	≤2.0
South	150	<40	≤5.0	<3.5

Ecoregion-based eutrophication criteria for nutrient (TP) and response variables: sestonic chlorophyll-a, daily dissolved oxygen flux (change) & biochemical oxygen demand; pH >9.0 (WQS) can be used as a response variable as well;



Conceptual model on impact of nutrient enrichment on biological condition and recreational quality for medium to large rivers



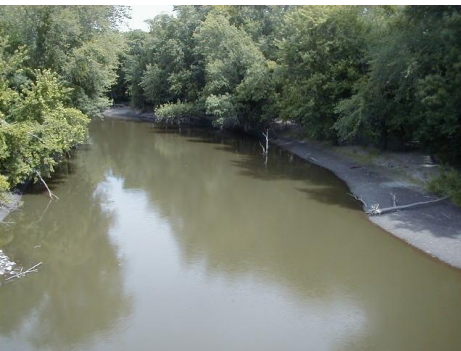
River Nutrient Study studies & data collection

- **1999 & 2000** - Initial EPA-funded studies focused on representative medium-large rivers in various ecoregions - e.g. Crow, Miss. & Rum (below) focus on non-wadeable, watershed area generally >1,000 mi²
- **2001** – Sampled a range of rivers to test relationships & expand spatial coverage
- **2006 & 2008** – expanded coverage to all ecoregions
- River nutrient dataset ~40 sites w/ nutrients, biology & diurnal measurement.
- Later incorporated data from 100's of biological monitoring sites for state-wide coverage both wadeable & non-wadeable;



Probe for continuous DO measurement

South Fork



North Fork



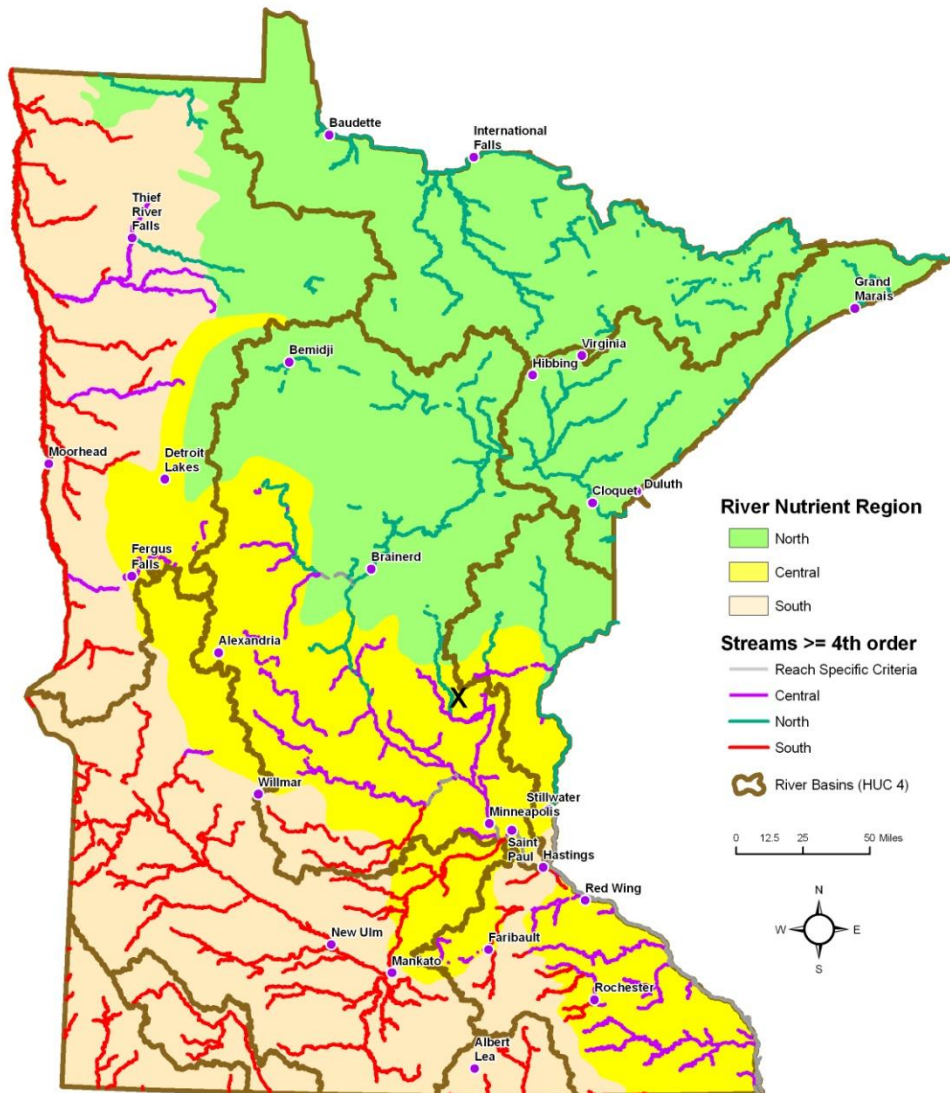
Miss. at Monticello



Rum



River Nutrient Regions in Minnesota



River Nutrient Regions (RNR)

Needed to regionalize criteria development because:

- 1) distinct differences among landform, land use, soil type, & stream water quality in MN &
- 2) EPA recommendation;
- 3) Consistent with lake standards

EPA Ecoregion map is the base map;
Rivers classified based on:

- Relative ecoregion composition;
- Review of reach-specific WQ;



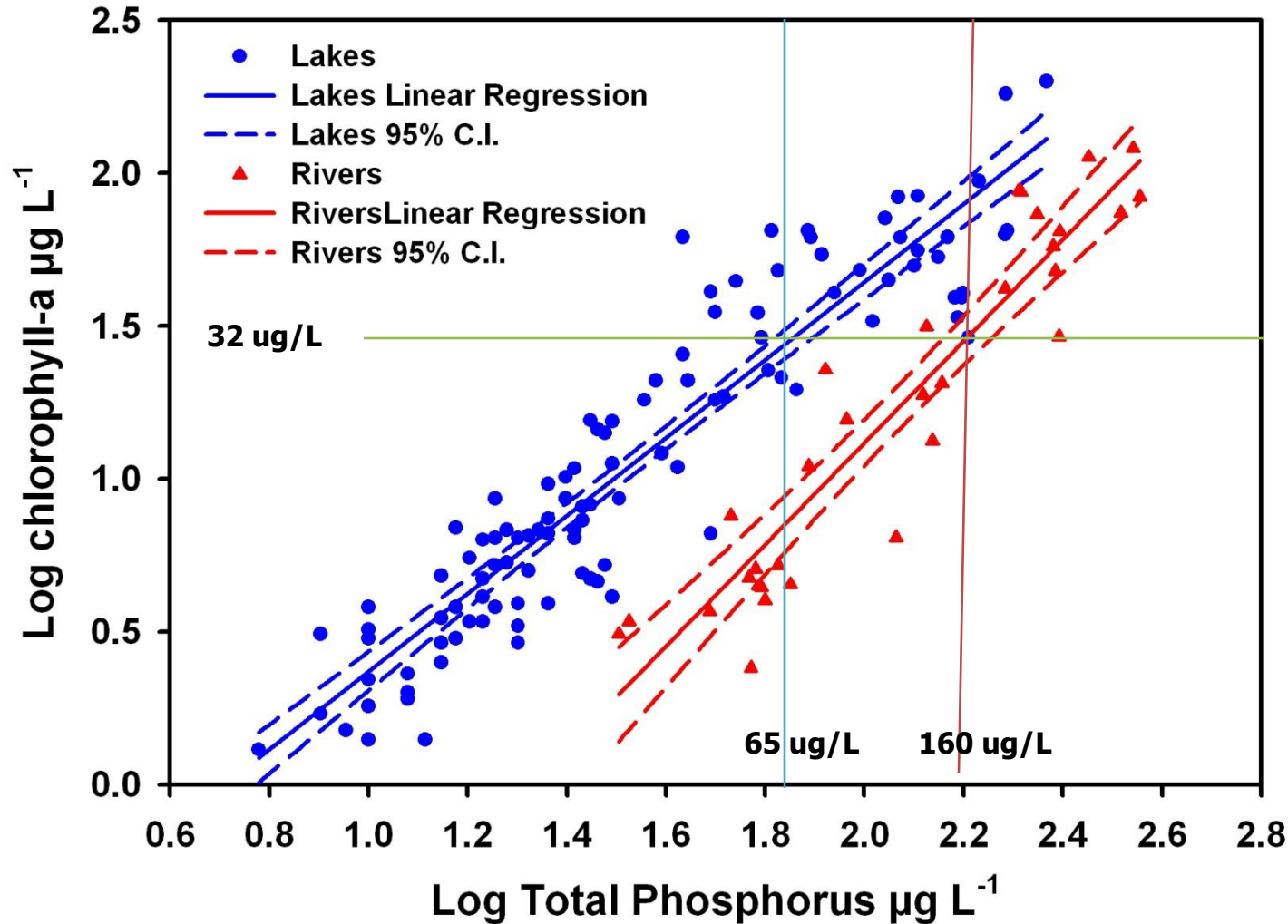
Minnesota
Pollution
Control
Agency

Criteria development: multiple lines of evidence

1. Spearman correlation: initial examination of relationships among TP, TN, Chl-T, DO flux, and biological metrics
 2. Linear regression: define relationships among TP, N, Chl-T, and DO flux
 3. Scatterplots: visualize relationships among biological metrics and stressors and begin threshold ID
 4. Quantile regression and changepoint analysis: threshold concentrations determined for wadeable vs. nonwadeable and on a region-specific basis
- Comprehensive literature review to provide further perspectives
 - **Use above to move from broad ranges to region-specific criteria**



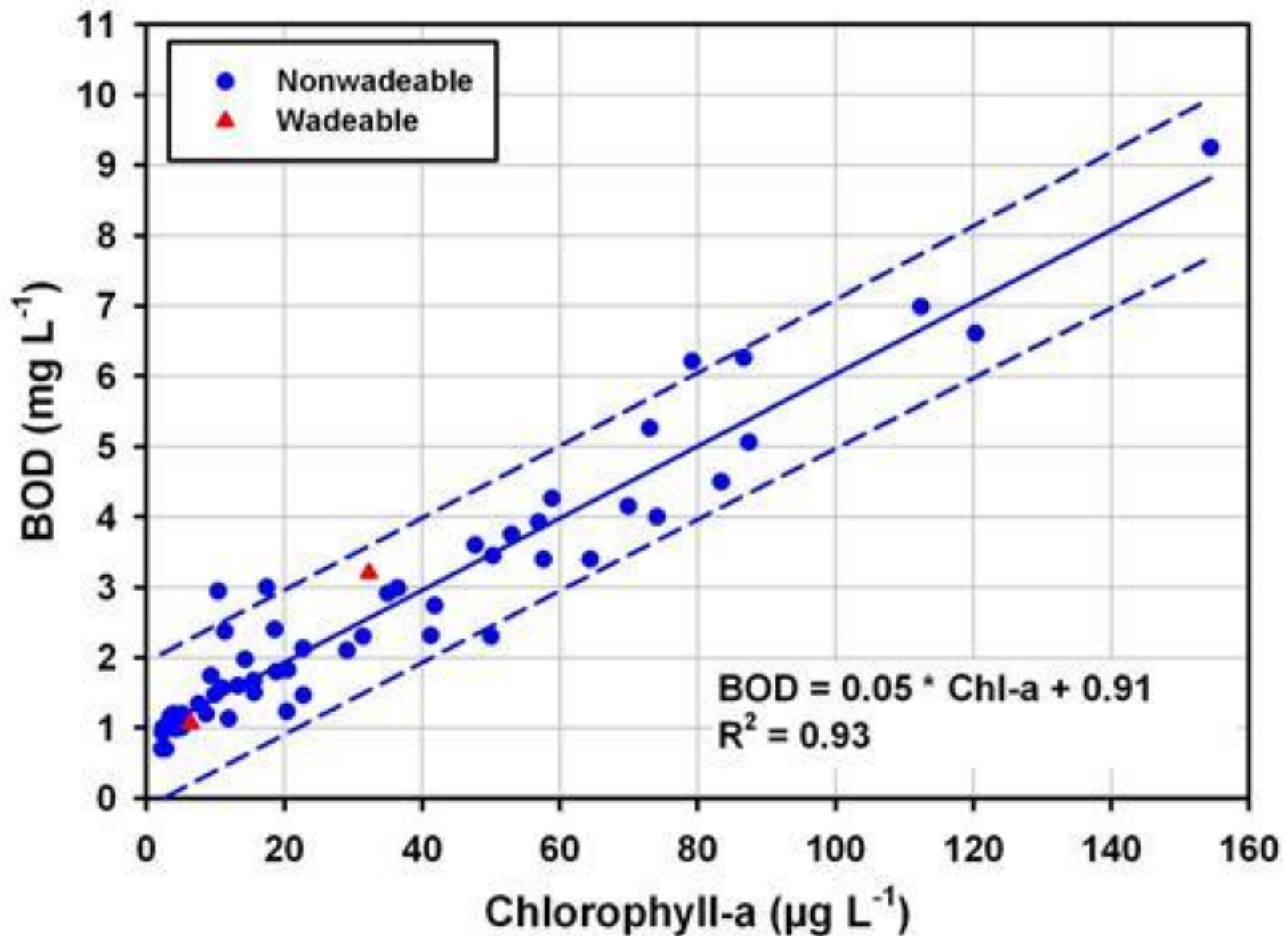
TP vs.chl-a regressions for reference lakes & rivers



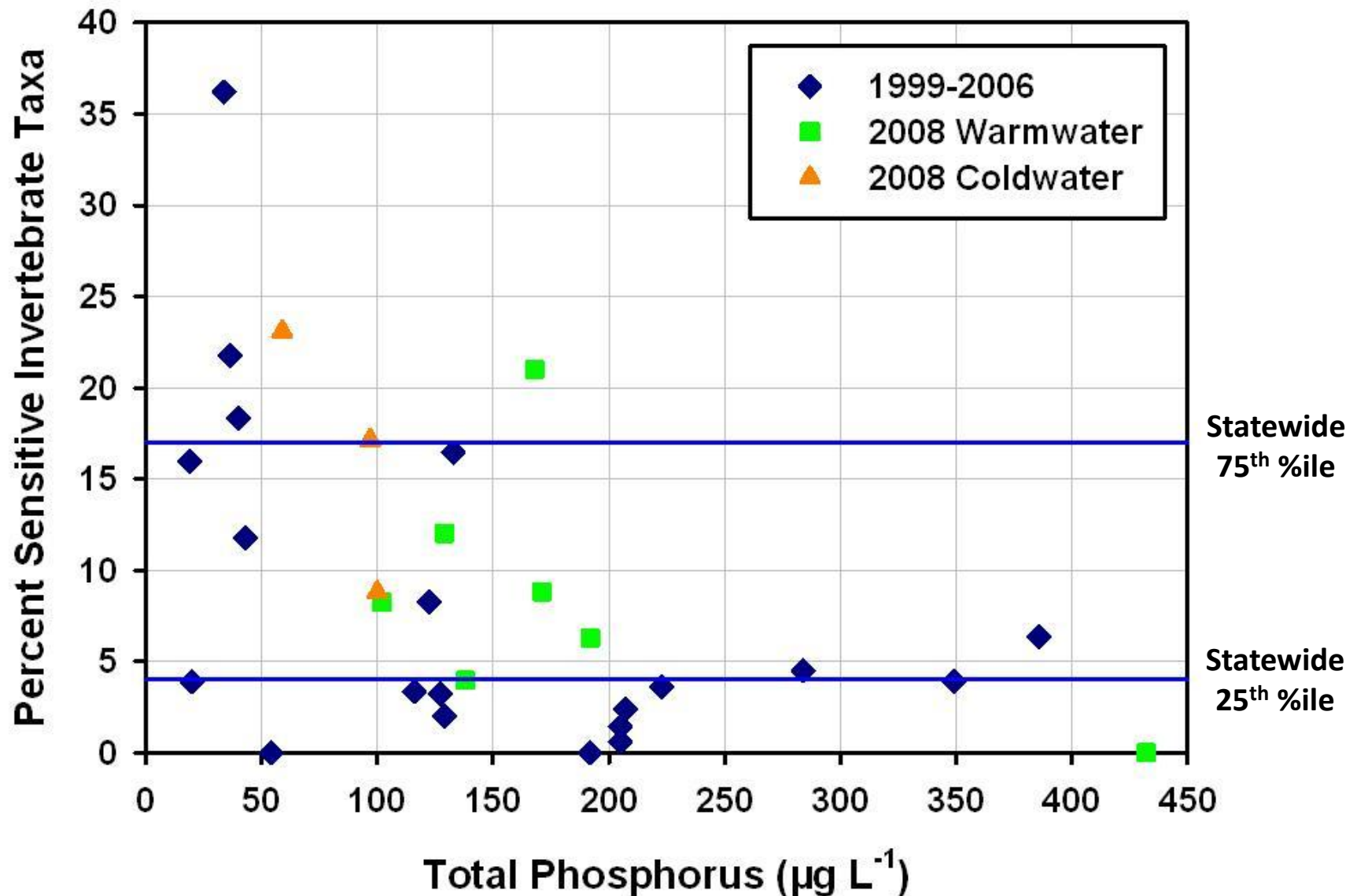
Established relationship among TP & Chl-a based on RN data for 31 rivers.

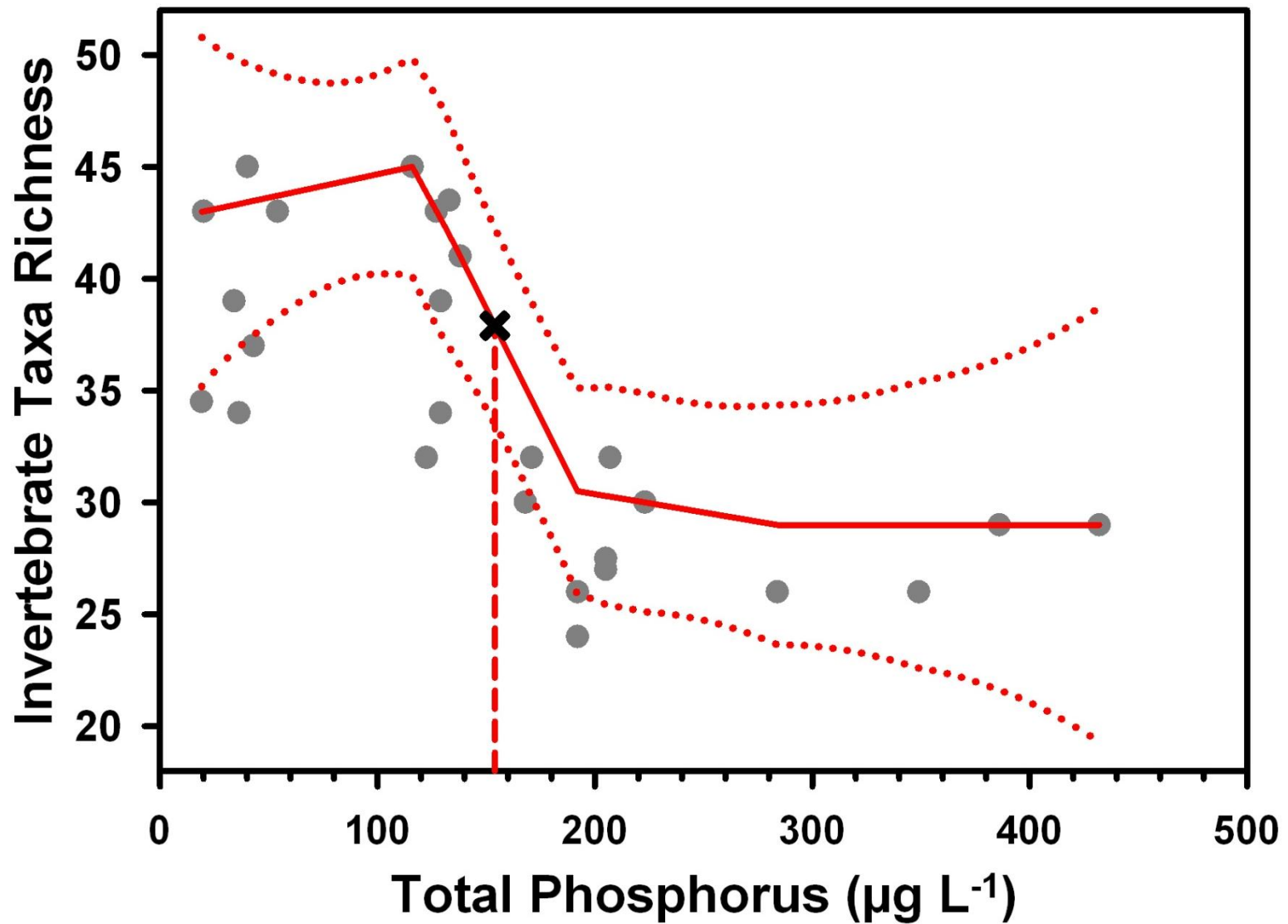
- Different relationship but equally as strong as lakes.
- Stream size, flow & turbidity influence relationships.

River chlorophyll (suspended algae) and BOD

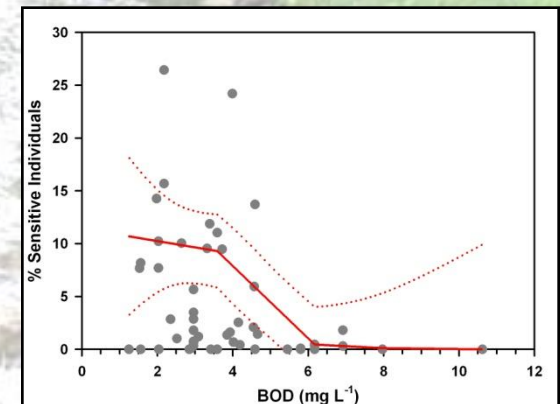
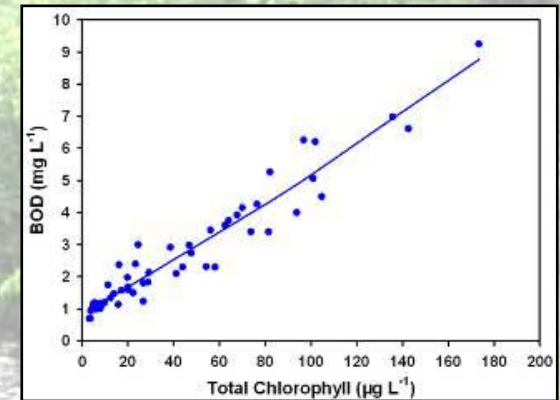
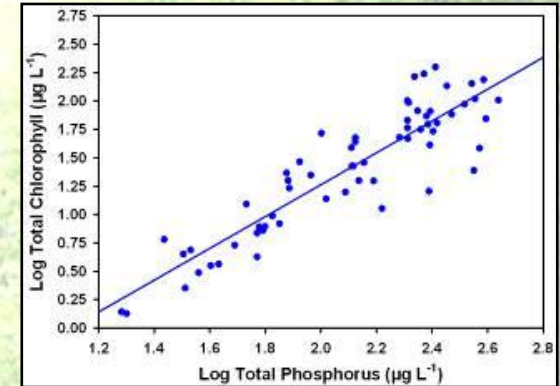
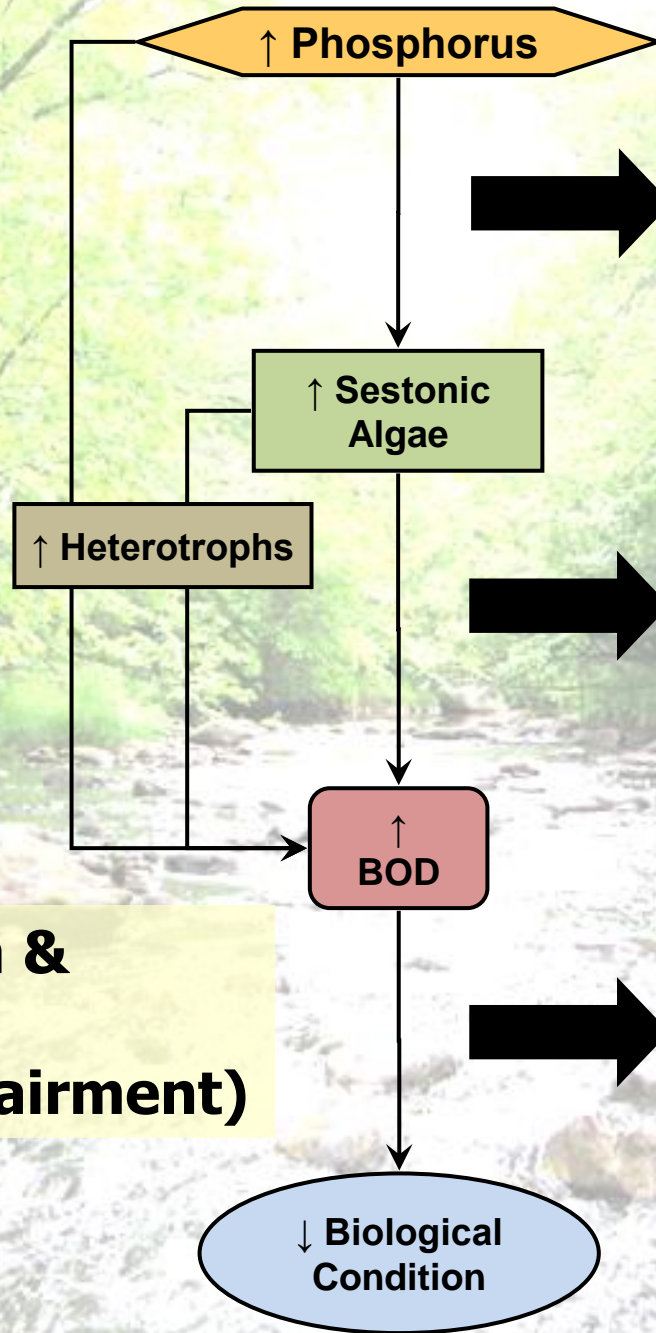
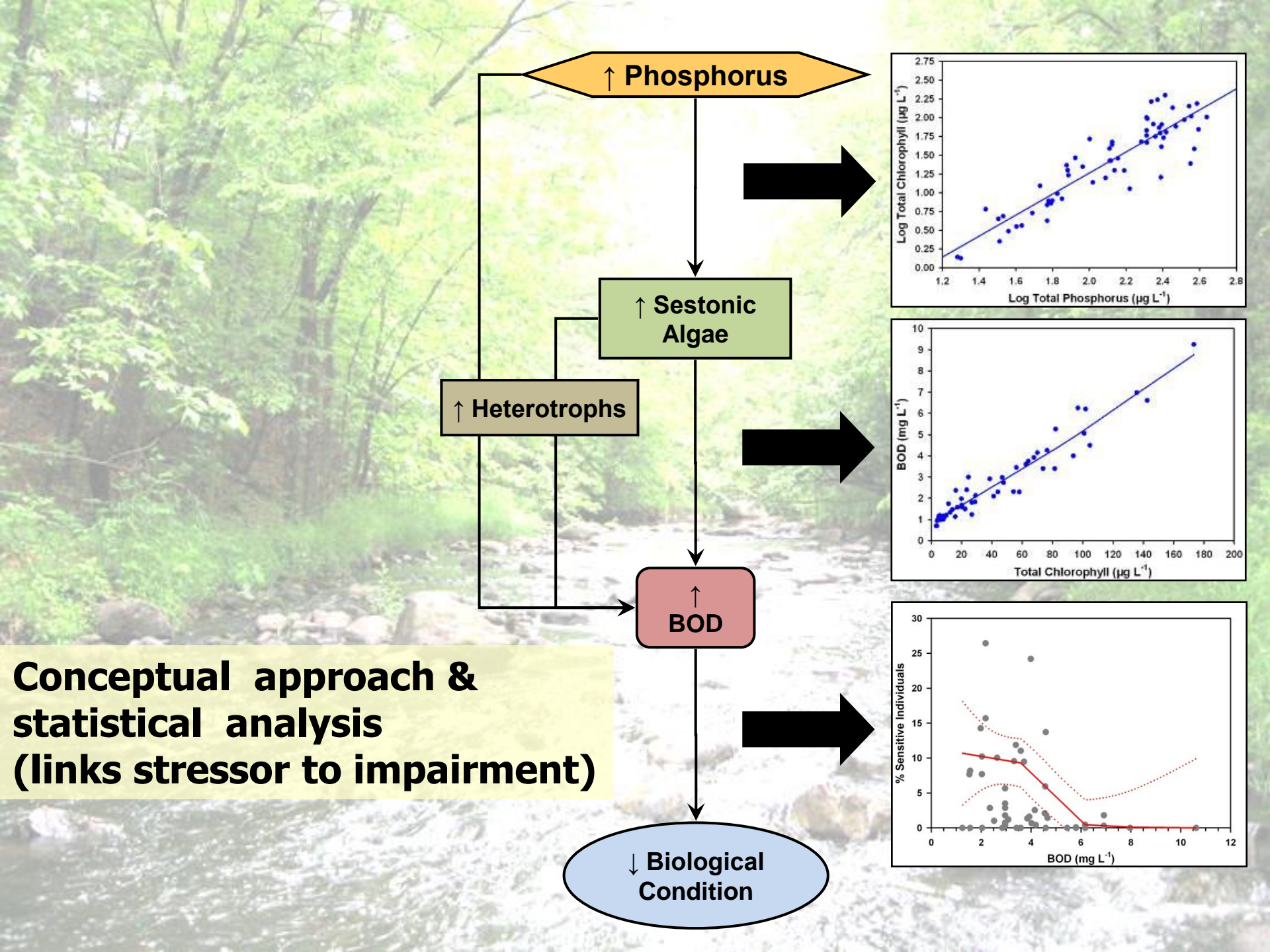


Phosphorus and Aquatic Life





Quantile (piece-wise) regression (with CI) describes relationships & ID threshold concentrations. Mid-point of 2 breakpoints used to interpolate TP.



Conceptual approach & statistical analysis (links stressor to impairment)

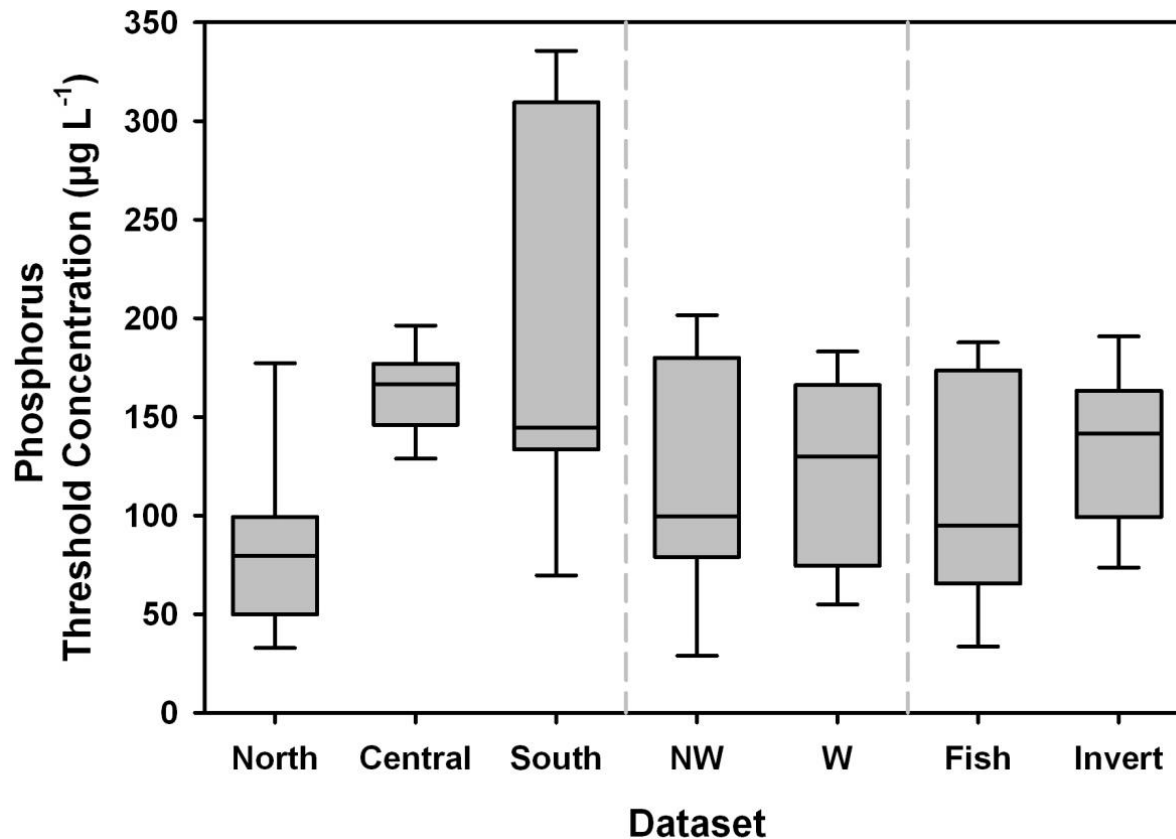


Minnesota
Pollution
Control
Agency

Threshold Concentrations

Threshold concentrations from
biological tests for:

- Region: north, central, and south
- River size: nonwadeable and wadeable
- Biological group: Fish and invertebrate





Minnesota
Pollution
Control
Agency

Draft river eutrophication criteria (summer-means).

	Cause	Response		
Region	TP µg/L	Chl-a µg/L	DO flux mg/L	BOD ₅ mg/L
North	55	<10	≤4.0	≤1.5
Central	100	<20	≤4.5	≤2.0
South	150	<40	≤5.0	<3.5

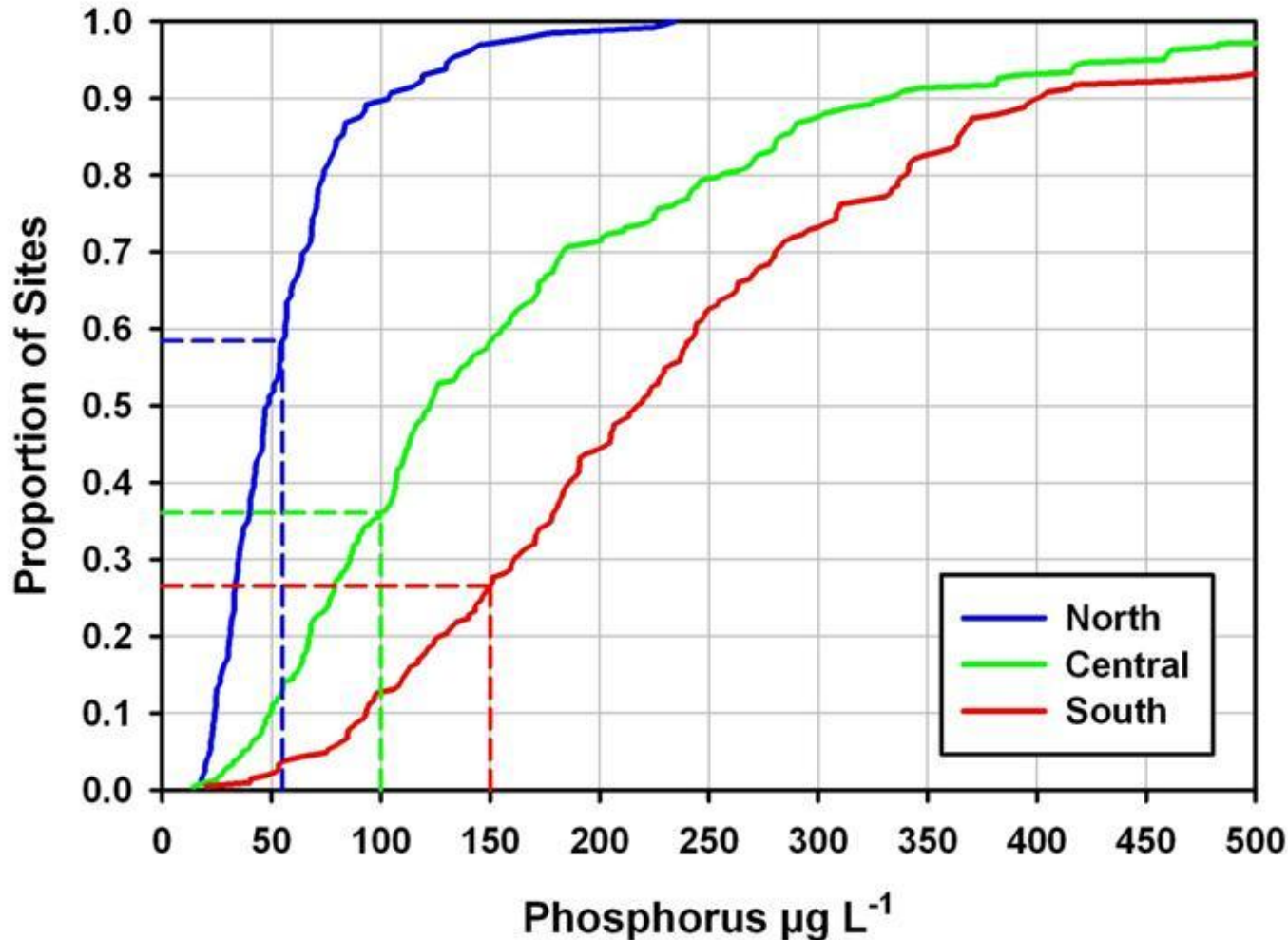
- Future assessments based on:
- Minimum of 2 summers & 6 or more obs./summer;
- Data from most recent 10 years;
- Must exceed cause & one or more response (stressors) to be deemed impaired (303(d) listed)





Minnesota

Draft criteria compared to RNR-based TP distribution.



Reflects distinct regional patterns

Based on summer-mean STORET data from 1995-2009 for:
128 (North), 239 (Central) and 209 (South) river sites.





Minnesota
Pollution
Control
Agency

Example assessment based on STORET data for most recent 10 years

Region / River Name	TP ug/L	Chl-a ug/L	BOD mg/L	303(d) list
North RNR	55	10	1.5	
Leech Lake River nr Ball Club	28		1.5	N
Pine River nr Mission, CSAH11	28		1.0	N
St. Croix River nr Danbury, WI	39	3	1.0	N
Mississippi River at Aitkin, MN	52	6	1.2	N
Central RNR	100	20	2.0	
Leaf River nr Staples, CSAH29	84	3	1.2	N
Sauk River nr St. Cloud, MN	172	25	2.6	Y
North Fork Crow River nr Rockford	253	56	3.5	Y
Cannon River at Welch, MN	190	16	2.6	Y
Mississippi River at Anoka	88	23	1.8	close
Rum River at St. Francis	125	19	1.9	close
South RNR	150	40	3.5	
South Fork Crow River at Delano	395	102	7.9	Y
Blue Earth River nr Rapidan	190	59		Y
Le Sueur River nr Rapidan	244	45		Y
Minnesota River at Judson	239	82		Y



Addressing excess attached algae:

Periphyton Chl-a $<150 \text{ mg/m}^2$ (mass/unit area)

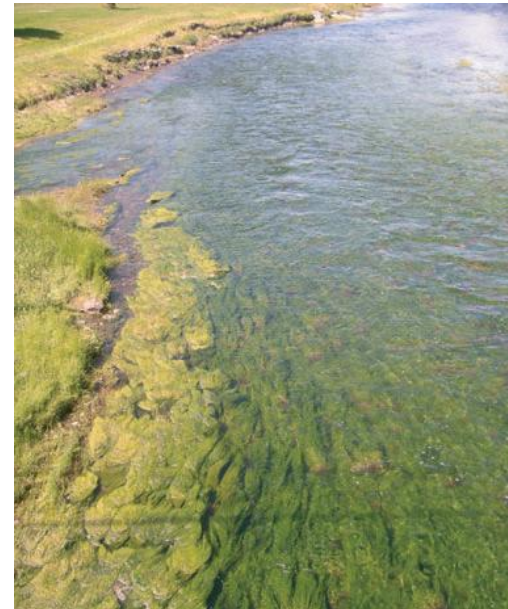
- Current scientific literature suggests a biomass concentration of $150 \text{ mg CHL } a/\text{m}^2$ protects streams' beneficial uses and higher biomass is considered polluted with loss of uses.
- This is a numeric translator of the general narrative WQS language that does not allow “noxious growth of algae.”
- Because it is a translator, there are no nutrient concentrations associated with this biomass WQS (requires stressor ID to determine causation).



Low

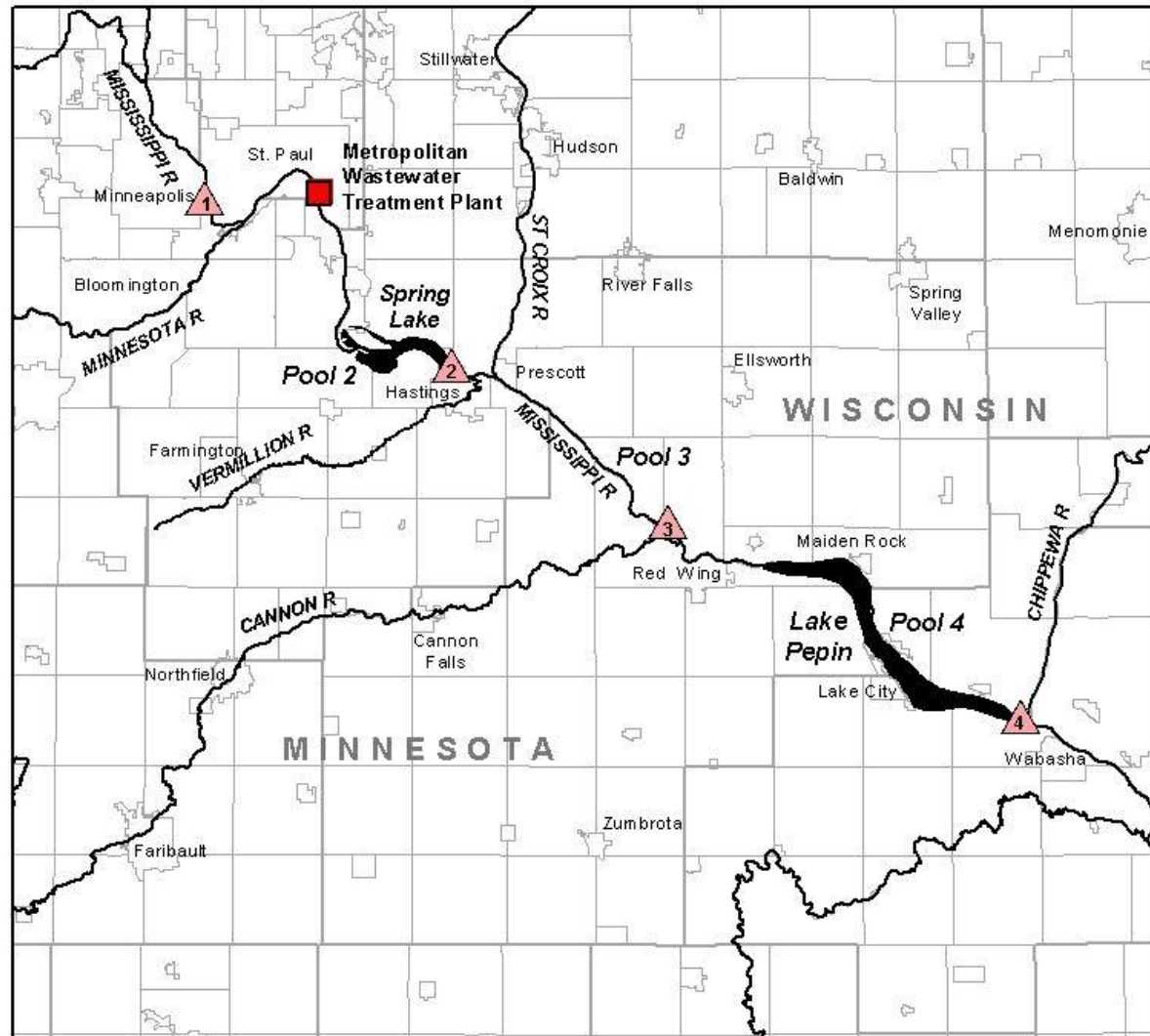


$\sim 150 \text{ mg/m}^2$

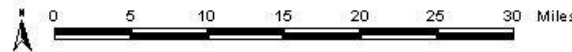


$>150 \text{ mg/m}^2$

Linking statewide river criteria with Lake Pepin & Miss. River navigational pool criteria



△ Upper Mississippi River Locks and Dams



Lake Pepin
Cathy Larson



Rivers -

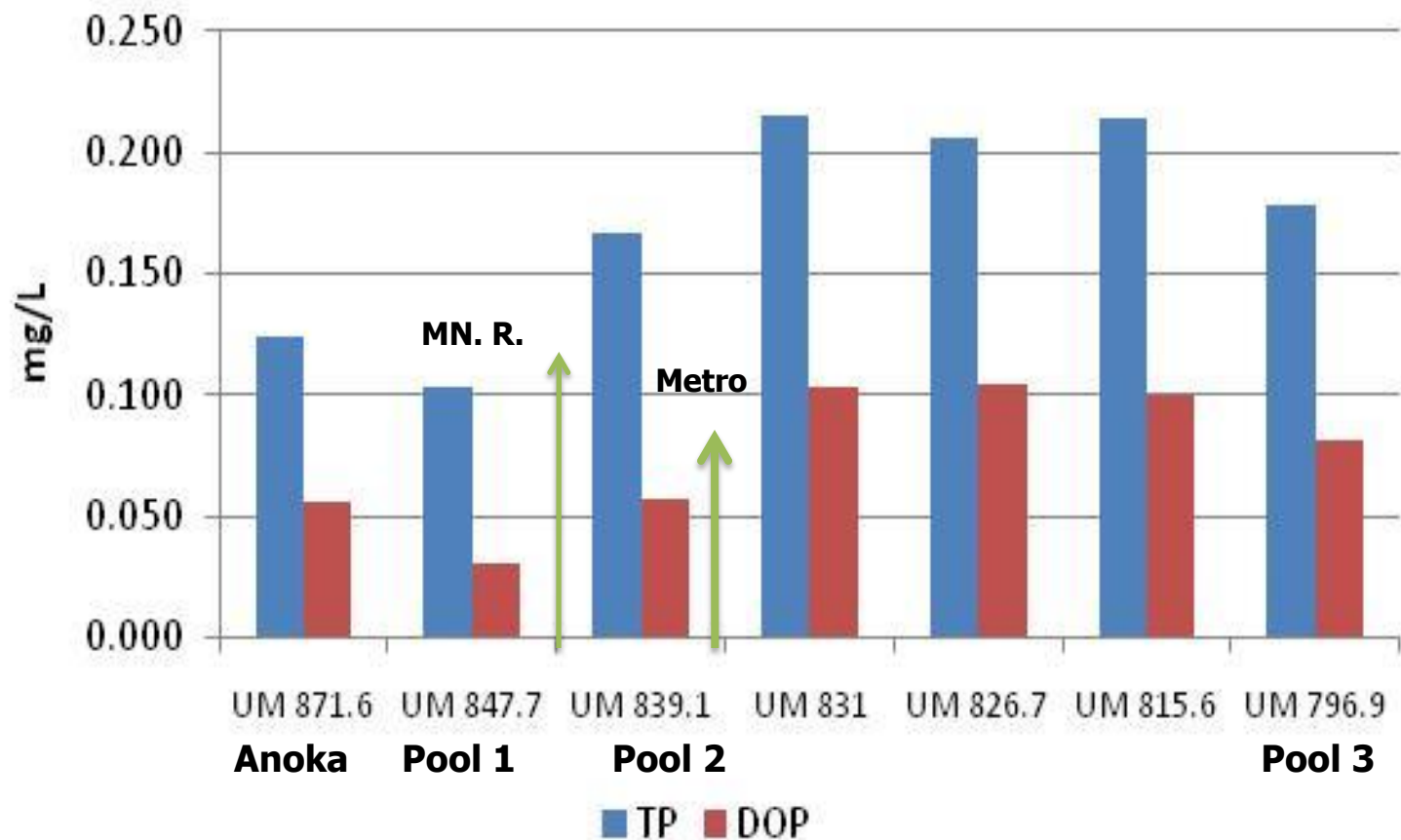
"Aquatic life" emphasis

Pools and Pepin - "Aquatic Recreation" emphasis

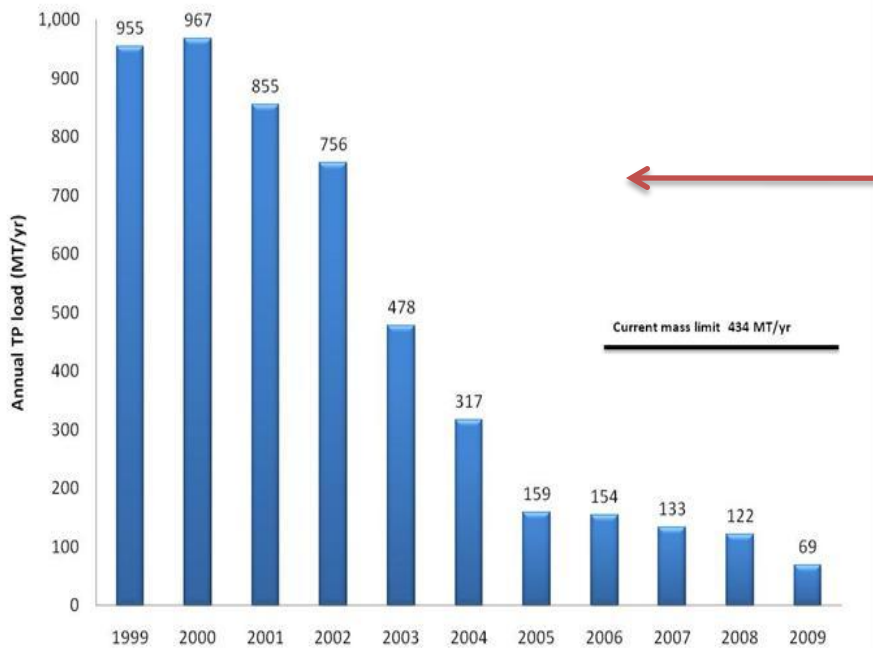


MCES data for rivers & Pools 1-3: Summer-mean Phosphorus 1993-2009

Mississippi River 1993-2009 summer-mean



Annual load of total phosphorus from the MCES Metro Plant from 1999-2009



Example of a major reduction in P loading

MCES Metro Plant P loading: 1999-2009

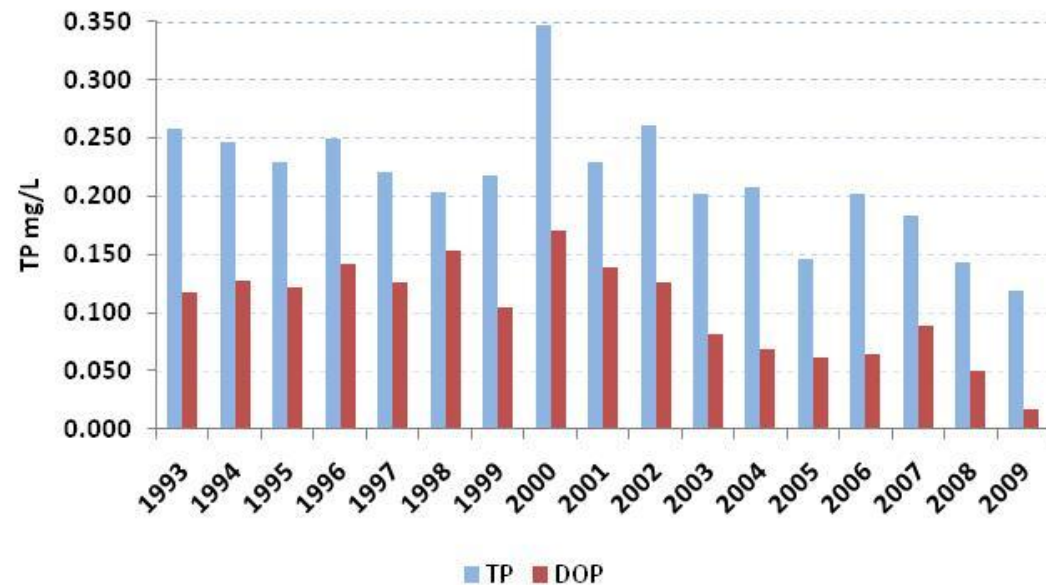
- Effluent reduced from ~3 mg/L to <0.5 mg/L by 2005;

Pools 2 & 3 TP:1993-2009

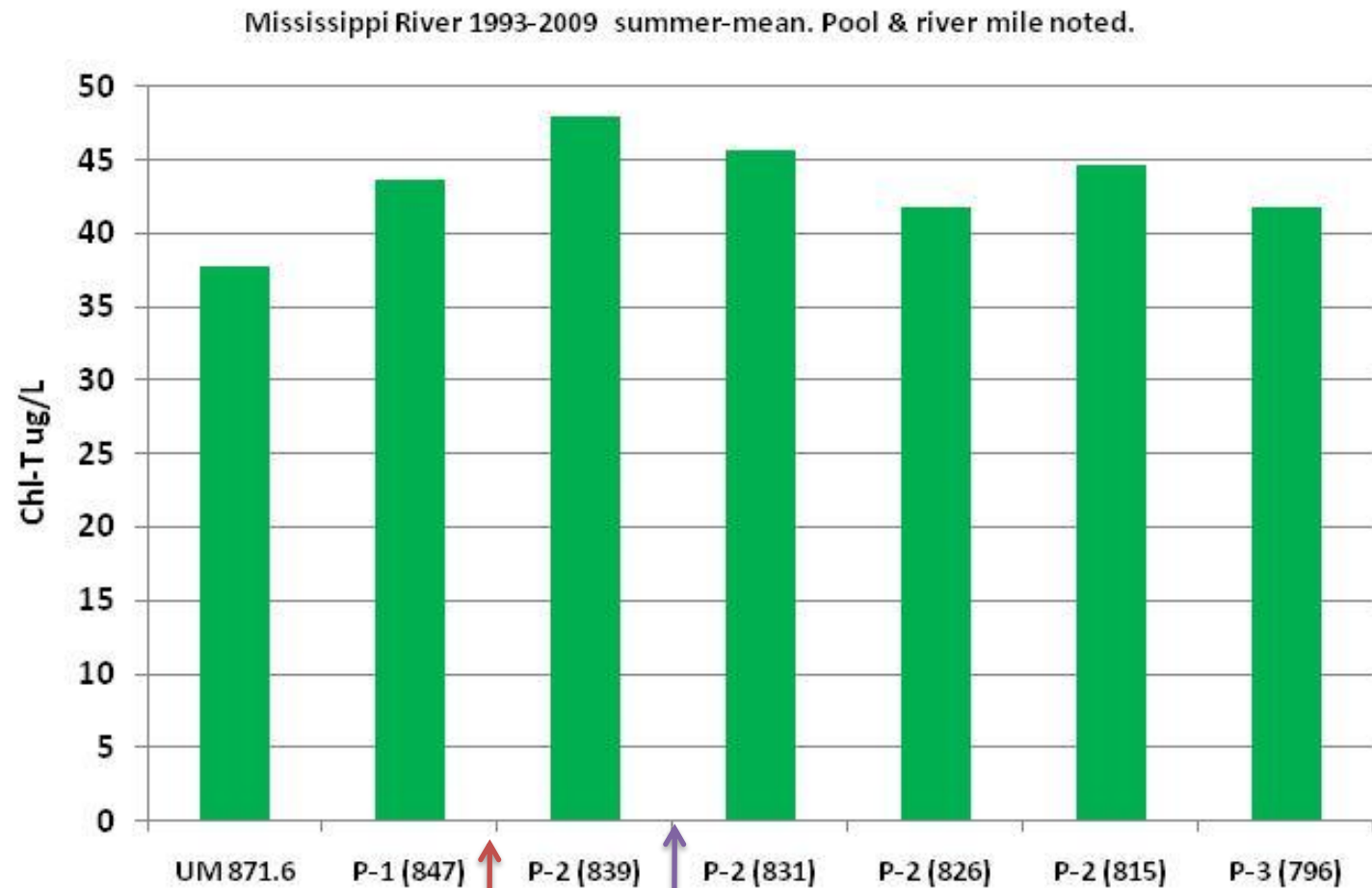
- Recent TP in Pools 2 & 3 <150 ug/L
- Evidence of periodic P limitation



Mississippi River Pool 2 (UM-831)



Summer-mean Chlorophyll: Anoka to Pool 3

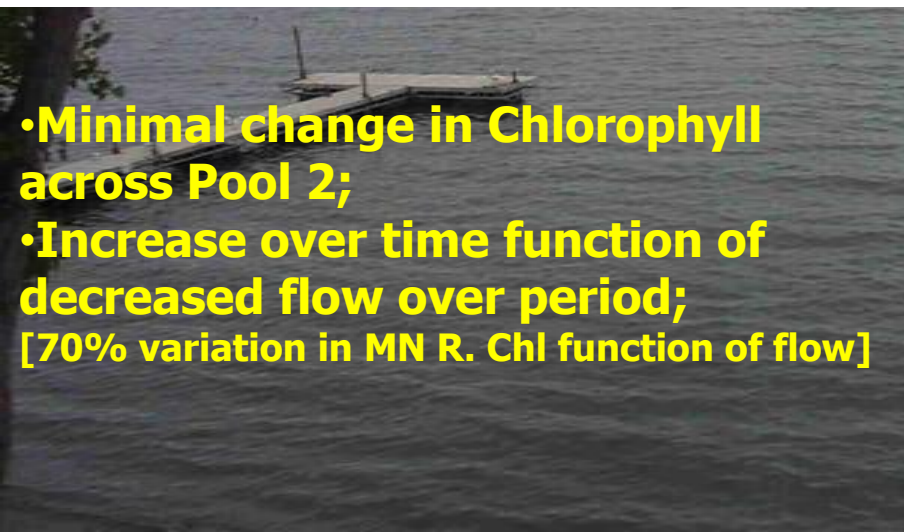
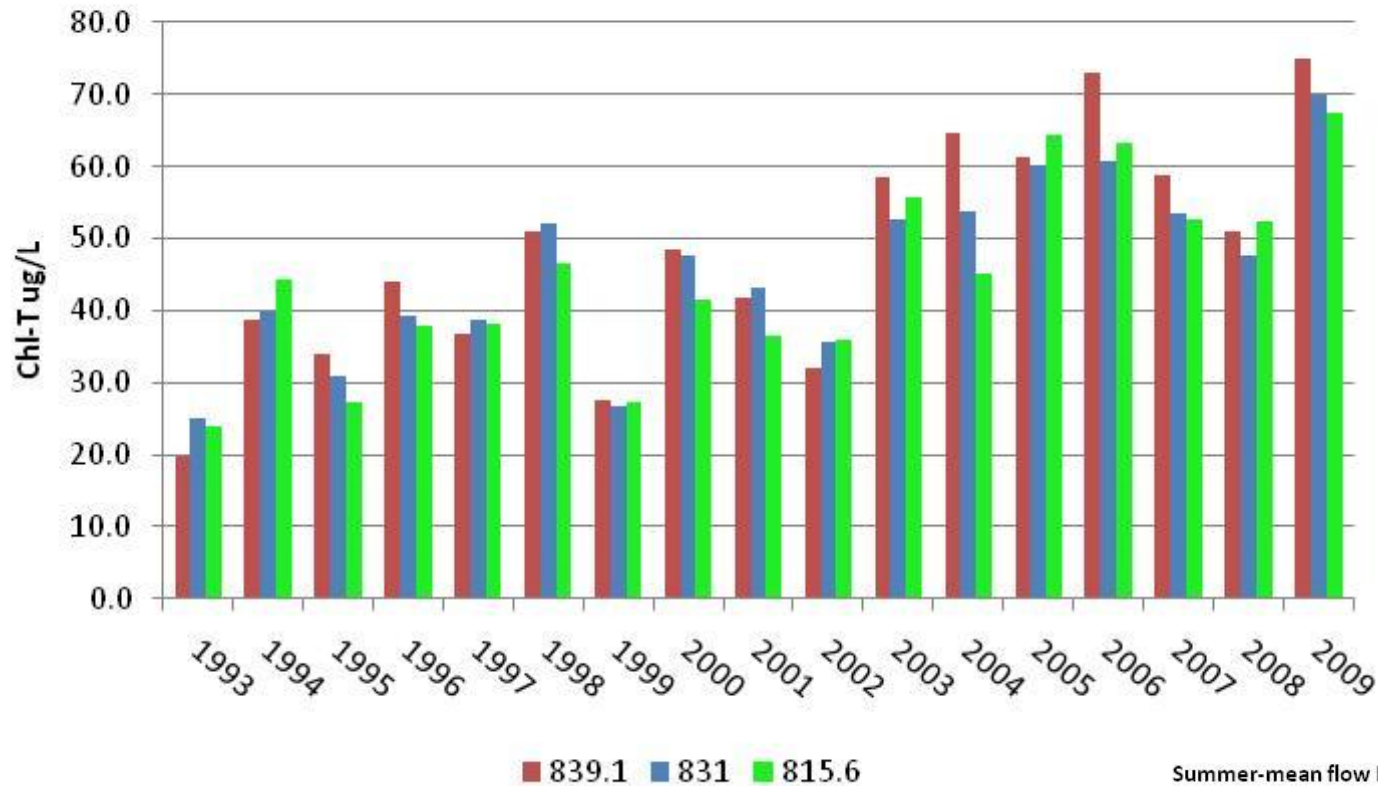


Minn. River

MCES Metro

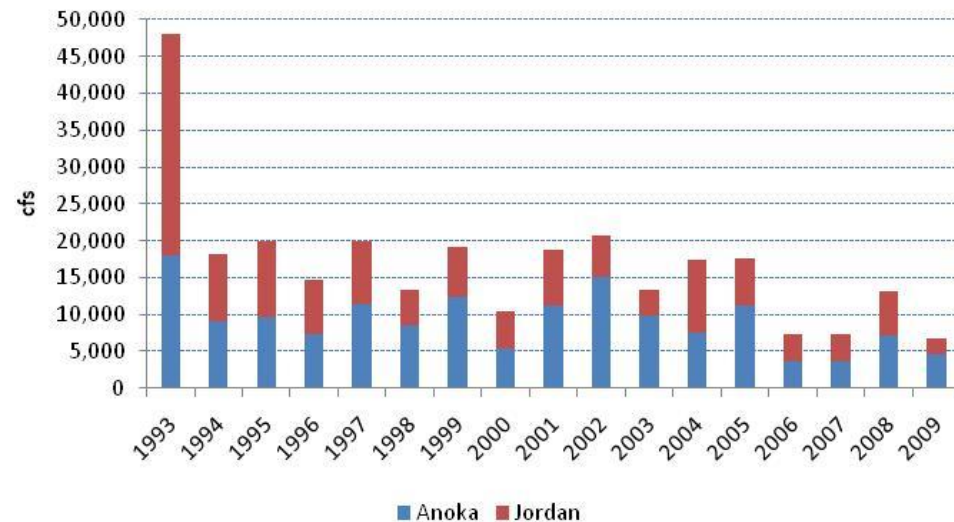
*Lake Pepin
Cathy Larson*

Mississippi River Pool 2 Chlorophyll River Mile: 839-815 (Spring Lake)



- Minimal change in Chlorophyll across Pool 2;
- Increase over time function of decreased flow over period;
[70% variation in MN R. Chl function of flow]

Summer-mean flow Miss. & Minn. Rivers



Lake Pepin Draft Eutrophication Criteria

Criteria & Considerations: TP = 100 ug/L

- Lower end of TP range for 1900-1960 time period;
- Supported by model based on 22-years of data
- Consistent with WI standard;
- Consistent with MN statewide river standards;

Criteria & Considerations: Chl-a = 28 ug/L

- Keep frequency of nuisance blooms (>50 ppb) to < 5% summer;
- Minimize dominance of blue-greens;

Modeled reductions needed to meet Pepin criteria:

- 50% reduction in Minn. & Cannon River TP & Chl-a;
- 20% reduction in Miss. & St. Croix Rivers TP & Chl-a;
- Reductions needed from point & nonpoint sources, good progress to date at MCES Metro facility;

Draft criteria for main-stem rivers, Miss. River pools, & Lake Pepin.
Concentrations expressed as summer averages.

River/Pool	Site (RM)	Data source	TP µg/L	Chl-a µg/L
Miss. @Anoka¹	UM-872	MCES	100	20
Pool 1²	UM-847	MCES	100	35
Lake St. Croix³		MCES	40	14
Minn. @Jordan¹	MI-39	MCES	150	40
Pools 2-3⁴	UM-815	MCES	--	35
Pepin⁵	4 sites	LTRMP	100	28
Pools 5-8⁶	Near-dam	LTRMP	--	35

¹ **Statewide river eutrophication criteria-based.**

² **Minimize frequency of severe blooms; Upstream criteria protect Pool 1.**

³ **MN lake criteria-based.**

⁴ **Minimize frequency of blooms & support Pepin requirements**

⁵ **Lake Pepin criteria based on mean from 4 sites.**

⁶ **Minimize frequency of severe blooms; upstream P requirements benefit lower pools.**

WI standard of 100 µg/L TP may apply to Pools 5-8 & inflowing rivers;

Challenges in Applying Criteria

- Miss. River pool criteria are “system goals” – not always cause-effect between TP and chl-a values at given site.
- Need to find upstream algae “hot spots” & focus TP reductions there:
 - Minn. River, N&S Fork Crow, Sauk, ...
- This will be done over time through TMDLs & watershed approach





Minnesota
Pollution
Control
Agency

Challenges 2

- Criteria designed to protect aquatic life and recreation of entire Mississippi River in Minnesota;
- Steep TP reductions needed upstream of Metro Area to benefit entire system.
- Need to emphasize targeted reductions for system-wide benefits





Minnesota
Pollution
Control
Agency

Summary

- Initial draft river criteria revised based on EPA review and comment; re-submitted to EPA August 2010.
- Pepin site specific and pool criteria technical reports also submitted to EPA;
- Linkages among these rivers, pools & Pepin are made & draft criteria reflect interconnectedness and need to protect downstream resources;
- Pepin criteria need be considered in a Miss. R. context & overall approach emphasizes upstream reductions in order to meet criteria and assure uses are met (i.e. not stand-alone goals to be pursued in isolation);





Minnesota
Pollution
Control
Agency

What's Ahead & Underway

- EPA R5 & HQ review underway;
- Public presentations planned for Nov.;
- Proposed nitrogen criteria based on nitrate-N toxicity, EPA bioassays recently completed
 - Current WQS for 2A & 2Bd 10 mg/L
 - Proposed aquatic life criteria ~5 mg/L
- Complete development of “Statement of Need & Reasonableness (SONAR)” and triennial review process during 2011;
- Finalize by 2012



River Nutrient Reports & Water Quality Rules

MORE INFORMATION:

Water Quality Standards Rule Revision

<http://www.pca.state.mn.us/water/standards/rulechange.html>

Streams: Algae Monitoring (1 journal article & 2 reports to EPA)

<http://www.pca.state.mn.us/water/biomonitoring/bio-streams-algae.html>

QUESTIONS/COMMENTS:

steven.heiskary@state.mn.us

651-757-2419



Minnesota Pollution Control Agency